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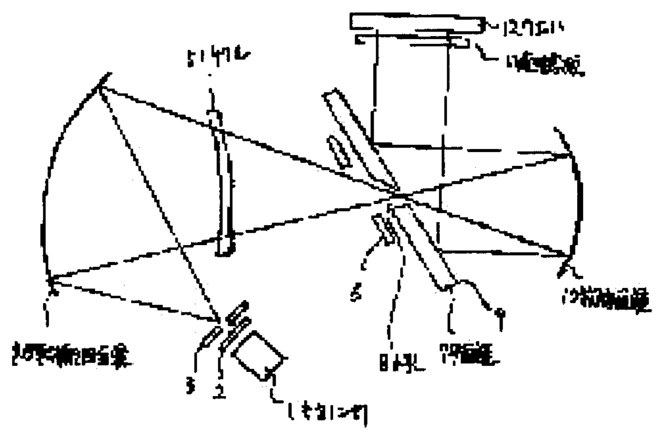
(54) OPTICAL SYSTEM FOR LSI MANUFACTURING CONTRACTION PROJECTION ALIGNER BY LIGHT

(57)Abstract:
PURPOSE: To obtain a mirror type stepper in which a short wavelength ultraviolet ray is used as a light source and which has a deep focal depth, a wide exposure area and a large numerical aperture.
CONSTITUTION: A light source is mounted at one focal point of a rotational elliptical concave mirror, the small hole 8 of the mirror 7 is mounted at the other focal point, and the hole 8 also becomes a focal point of a parabolic mirror 10. A high coherent light is used as a light source thereby to deepen a focal depth, to remove various aberrations and to improve an effective numerical aperture. Further, a reticle image is increased larger than an image on a wafer and the width of the wavelength of an illumination light is increased thereby to prevent deterioration of the image due to the use of the coherent light. In this case, its resolution is improved when transparent liquid is filled between optical systems.



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(54) Title of the Invention: Optical system of LSI fabrication reduction projection lithography apparatus by light

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(54) Abstract
[Object]
It is to obtain a mirror-type stepper with the light source of the ultraviolet light at the short wavelengths, the deep depth of focus, the broad exposure area and the large numerical number.
[Configuration]
The light source is arranged at one focus point of revolving elliptic concave mirror, and small opening 8 of plane mirror 7 is arranged at another focus point thereof, and small opening 8 is also the focus point of parabolic mirror 10.

[Effect]

With the high-coherent light as the light source, the depth of focus is made deeper to eliminate various aberrations, and the effective numerical aperture is improved. Furthermore, by making the reticle image larger than the image on the wafer, and making the wavelength bandwidth of the illumination light broader, the degradation of the image by use of the high-coherent light is prevented. In this case, the resolving power is improved when the space among the optical system is filled with the transparent liquid.

[What is claimed is]
[Claim 1]

An optical system of a LSI fabrication reduction projection lithography apparatus comprising:

an illumination unit of converging light on one point in front of a reticle; and

a plane mirror being arranged by aligning a small opening of the plane mirror with the one point on which the light is converged, wherein a mirror with a concave surface facing to a mirror surface of the plane mirror is arranged.

[Claim 2]

The optical system of the LSI fabrication reduction projection lithography apparatus set forth in claim 1, wherein the optical system is configured to fill a space of the optical system with a transparent liquid, and circulate the transparent liquid.

[Detailed description of the Invention]
[0001][Field of the Invention]

The present invention relates to an optical system of a mirror-type LSI fabrication reduced projection lithography apparatus (a stepper) by means of light.

[0002][Prior arts]

There has been the conventional mirror-type 1:1 magnification batch projection lithography apparatus or the lens-type stepper.

[0003][Problems to be solved by the Invention]

In the optical system of the mirror-type 1:1 magnification batch projection lithography apparatus in the prior art, only the line image at 1:1 magnification can be attained, so this system has had the problem that it is quite difficult to make the fine alignment of the mask image, and the effect of the dust becomes large, and it is difficult to remedy all the defects or the like.

[0004]

In the conventional lens-type stepper, the transparent substance in the lens usable in the ultraviolet light at the

short wavelengths is few, and the transparency of the lens is low, or there is another problem on the endurance of the lens.

[0005]

An object of the present invention is to provide a stepper having a mirror-type optical system capable of using the ultraviolet light at the short wavelengths, and having a high resolving power and deep depth of focus with a broad exposure area.

[0006][Means for solving the problems]

In order to attain the above object, in an optical system of a stepper according to the present invention, high-coherent light with a relative broad range of the wavelengths as a light source is caused to be converged on one point in front of a reticle by a condensing mirror with a concave surface, and

[0007]

A plane mirror is arranged by aligning a small opening of the plane mirror with the one point on which the light is converged, and

[0008]

A mirror with a concave surface facing to a mirror surface of the plane mirror is arranged in such a manner that a focus point of the concave mirror is aligned with the small opening of the plane mirror.

[0009]

Light from the light source is illuminated on a reticle, and passes through the small opening of the plane mirror, and turns into almost collimated light on the concave mirror, and a very thin transparent window plate is arranged perpendicular to the traveling collimated light reflected on the same plane mirror, and

[0010]

A wafer is loaded very close to the transparent window plate, and a reticle image is reduced and formed on the wafer.

[0011]

The reticle is fabricated on a curved surface correcting for curvature of field.

[0012]

A space among the optical system is filled with a transparent liquid, and circulating the transparent liquid is very effective due to a later-described reason.

[0013][Action]

Assuming that light passing through the reticle is high coherent, and a wavelength is λ, a diameter of condensing concave mirror is D, and a focal length is f, 84.6 % of all of a light amount is converged on the small opening of the plane mirror in front of the reticle within a radius of $\gamma=1.22\lambda f/D$. A diffraction pattern of the reticle occurs around its perimeter.

[0014]

According to the present invention, as the reticle and the transparent window plate are made from synthetic fused silica, their surfaces can be smoothly grinded, whereby an effect of the surface by use of the high-coherent light is low.

[0015]

According to the present invention, an outside is insulated by the transparent window, so convection of air is few, and moreover, an entry of the dust is prevented. When the present invention as a whole is configured with a near-vacuum structure, the convection of air and the effect of the dust become small.

[0016]

On the contrary, by filling the space among mirror optical system with the transparent liquid, and circulating this transparent liquid, the effect of the surfaces of the reticle and the transparent window plate become small, and moreover, the effect of the dust becomes small. As the light is absorbed by the transparent liquid, a change in refractive index of light due to increase in temperature is prevented.

[0017]

As the transparent window is very thin, and arranged perpendicular to the light reflected on the concave and plane mirrors, chromatic aberration does not occur.

[0018]

According to the present invention, an electric dust collector is arranged at the perimeter of the small opening of the plane mirror between the plane mirror and the reticle, so the dust in the stepper is eliminated, and the entry of the dust into the mirror optical system through the small opening of the plane mirror is prevented.

[0019]

According to the present invention, the more an image pattern on the reticle has transparent parts, the better the image pattern becomes, so it is necessary to take this into account upon image-formation. Depending upon the image pattern, there may be a case where it is better to invert a photoresist image.

[0020]

In the LSI fabricated by the stepper of the present invention, a deficit portion corresponding the small opening of the plane mirror exists at the center, but the small opening is the order of 1 mm in diameter, there is no effect on LSI chip density. When the light amount of the light source can be made large, it is a matter of course that the diameter of the small opening can be set to be further smaller.

[0021][Preferred example embodiments]

Example embodiments being made with reference to accompanying drawings, in Fig. 1, xenon lamp 1, filter 2, slit 3, revolving elliptic concave mirror 4, reticle 5, small opening 8 of plane mirror 7, parabolic mirror 10, plane mirror 7, transparent plate 11 and wafer 12 are arranged in order of this sequence along an optical path of the light from xenon lamp 1, and at one focus point of the revolving elliptic concave mirror is arranged slit 3, and at another focus point thereof is arranged small opening 8 of plane mirror 7. Furthermore, small opening 8 is concurrently a focus point of parabolic mirror 10, too. In this case, mirror surface 9 of plane mirror 8 is arranged facing to parabolic mirror 10, and electric dust collector 6 is attached to the perimeter of small opening 8.

[0022]

Instead of xenon lamp 1, there is an example embodiment using an excimer laser causing an oscillated wavelength to be excited by mixing several kinds of gasses like ArF, KrF, etc. as the light source.

[0023]

There is an example embodiment using a lens for aberration corrections instead of transparent window plate 11.

[0024]

There is an example embodiment using another concave mirror such as a spherical mirror, a hyperboloid mirror, etc. instead of parabolic mirror 10.

[0025]

According to an example embodiment shown in Fig. 2, the space among the optical system is filled with the transparent liquid, and the transparent liquid is caused to be circulated. Reticle 5 is immersed in tank 13 filled with the transparent liquid.

[0026][Effect of the Invention]

As the present invention is configured as described above, the following effects described below are attained.

[0027]

As the light source for the reticle illumination uses the high-coherent light, and the light is caused to be converged on the one point in front of the reticle by the revolving elliptic concave mirror, 84.6 % of all of the light amount is converged on the small opening of the plane mirror in front of the reticle within the radius of $\gamma = 1.22\lambda f/D$ where the wavelength is λ, the diameter of the revolving elliptic concave mirror is D, and the focal length is f. The diffraction pattern of the reticle occurs around the perimeter of the small opening, but the center point of the small opening is very high in the light amount in comparison with a perimeter ring-shape fringe portion having a light wavelength width at the small opening, so the rate of the diffraction occurrence due to the light passing through the fringe portion of the small opening becomes very low. Therefore, reduction in resolving power due to the light passing through the small opening is very small. This effect is getting larger

as a size of the small opening is close to the radius of $\gamma = 1.22\lambda f/D$.

[0028]

Most of the light reaching each point of the images on the surface of the wafer are the light reflected at a corresponding very tiny range of the parabolic mirror, so that depth of focus is also deep, and the aberrations other than the curvature of field and a distortion becomes very small.

[0029]

Furthermore, most of the light reaching each point of the images on the surface of the wafer are the light reflected at the corresponding very tiny range of the parabolic mirror, so that an effective numeral aperture becomes larger than the mathematical numeral aperture of the parabolic mirror.

[0030]

With the high-coherent light as the illumination light source, a speckle noise, etc. is brought about due to a diffraction phenomena of the reticle image, but the present invention is a type reducing the reticle image up to the order of 1:10, so that the reticle image pattern can be made large and no chromatic aberration allows the wavelength width to be broader, whereby there is no degradation of the image even if the high-coherent light is used as the light source.

[0031]

With the stepper of the present invention, the exposure area of the order of ϕ 30 mm, and the mathematical numerical aperture of the order of 0.35 (the effective numerical aperture is much larger) can be attained.

[0032]

As the present invention uses the mirror-type optical system, the ultraviolet light at the short wavelengths can be used than the stepper using the lens-type optical system.

[0033]

By filling the space among the optical system with the transparent liquid, the same effect as light of λ / η is used can be attained where the wavelength of the light is λ, and the

refractive index of the transparent liquid is η.

[Brief description of the drawings]

Fig. 1 is a schematic block diagram of one example embodiment of the present invention.

Fig. 2 is a schematic diagram of the reticle fringe portion of the example embodiment where the optical system of the stepper of the present invention is filled with the transparent liquid.

[Description of the reference codes]

1 XENON LAMP
2 FILTER
3 SLIT
4 REVOLVING ELLIPTIC CONCAVE MIRROR
5 RETICLE
6 ELECTRIC DUST COLLECTOR
7 PLANE MIRROR
8 SMALL OPENING
9 SURFACE OF PLANE MIRROR
10 PARABOLIC MIRROR
11 TRANSPARENT WINDOW PLATE
12 WAFER
13 TANK FOR FILLING TRANSPARENT LIQUID
14 TRANSPARENT LIQUID FLOW FILLING OPTICAL SYSTEM

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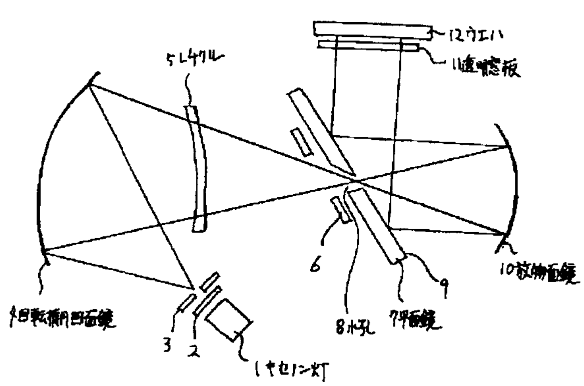
(54)【発明の名称】　光によるＬＳＩ製造縮小投影露光装置の光学系

(57)【要約】
〔目的〕　短波長紫外線を光源とした、焦点深度が深く露光面積が広くかつ開口数の大きい、ミラータイプのステツパを得る。
〔構成〕　回転楕円凹面鏡の一方と焦点に光源を，もう一方の焦点に平面鏡７の小孔８を設置し、かつその小孔８は放物面鏡１０の焦点にもなっている。
〔効果〕　高コヒーレント光を光源とすることにより、焦点深度を深くし種々の収差を除き実効開口数を向上した。又レチクル像をウエハ上の像より大きくとることと、照射光の波長域幅を広くとることにより高コヒーレント光使用による像の劣化を防いでいる。この時光学系間を透明な液体で満たすと解像力が向上する。



【特許請求の範囲】

〔請求項１〕　レチクルの前方の一点に集中する照射機構を有し、その光の集中する一点に平面鏡の有する小孔を一致して平面鏡を設置し、その平面鏡の鏡面の対面に凹面鏡を設置したことを特徴とするＬＳＩ製造縮小投影露光装置の光学系。

〔請求項２〕　光学系の間の空間を透明な液体で満たし、その透明な液体を循環さしている構造の請求項１記載のＬＳＩ製造縮小投影露光装置。

【発明の詳細な説明】

〔０００１〕〔産業上の利用分野〕本発明は、ミラータイプの光によるＬＳＩ製造縮小投影露光装置（ステツパ）の光学系に関する。

〔０００２〕〔従来の技術〕従来ミラータイプの等倍一括投影露光装置、レンズタイプのステツパがある。

〔０００３〕〔発明が解決しようとする課題〕従来のミラータイプの等倍一括投影露光装置の光学系では、等倍率の線状の像しか得られていないので、マスク像の精密位置合わせが難しく、塵埃による影響が大きく、全欠陥を修正することが困難である等の問題があった。

〔０００４〕従来のレンズタイプのステツパでは、短波長紫外線でレンズに使用可能な透明物質の少なさ、透明度の低さ、又レンズの耐久性の問題があった。

〔０００５〕本発明は、短波長紫外線を使用することのできるミラータイプの光学系を有し高解像度、広い露光面積で深い焦点深度を有するステツパを提供することを目的としている。

〔０００６〕〔課題を解決するための手段〕上記目的を達成するために、本発明ステツパの光学系においては、比較的広い波長域の高コヒーレント光を光源とし、集光凹面鏡にてレチクルの前方の一点に集中さし

〔０００７〕その光の集中す一点に平面鏡の有する小孔を一致して平面鏡を設置し、

〔０００８〕その平面鏡の鏡面の対面に凹面鏡を設置し、その凹面鏡の焦点と平面鏡の小孔とが一致する様にする。

〔０００９〕光源からの光がレチクルを照射し、平面鏡の小孔を通過し凹面鏡でほぼ平行光線となり、同じ平面鏡で反射して進行する平行光線に垂直な極めて薄い透明窓板を設置し、

〔００１０〕その透明窓板に極めて近接して、ウエハを設置しそのウエハ上にレチクル像を縮小結像する。

〔００１１〕そしてレチクルは、像面彎曲を補正する曲面に作製している。

〔００１２〕光学系の間の空間を透明な液体で満たし、その透明な液体を循環さすことが後記する理由により効果的である。

〔００１３〕〔作用〕レチクルを透過した光も高コヒーレントであり、波長λ，集光凹面鏡の口径Ｄ，焦点距離をｆとすると、γ＝１．２２λｆ／Ｄの半径内に全光量の８４．６％がレチクルの前方にある平面鏡の小孔に集中する。その周囲はレチクルの回折像を呈する。

〔００１４〕本発明ではレチクル、透明窓板は合成石英で出来ているので、表面を滑らかに研磨でき、高コヒーレント光使用による表面の影響が小さい。

〔００１５〕本発明では、透明窓でもって外界と隔絶されているので、空気の対流が少なく又塵埃の侵入を防いでいる。本発明全体を真空に近づけると、空気の対流や塵埃の影響が小さくなる。

〔００１６〕反対にミラー光学系の間の空間を透明な液体で満たし、その透明な液体を循環さすことにより、レチクル，透明窓板の表面の影響は小さくなり、又塵埃の影響が小さくなる。そして透明な液体に光が吸収されるための温度上昇による光の屈折率を変化を防いでいる。

〔００１７〕透明窓は極めて薄く、凹面鏡と平面鏡とで反射された光と垂直に設置されているので、色収差は生じない。

〔００１８〕本発明では、平板鏡とレチクルとの間に平板鏡の小孔の周囲に電気集塵装置を設置しているので、ステツパ内の塵埃を取り除き、平板鏡の小孔を通じてのミラー光学系への塵埃の侵入を防いでいる。

〔００１９〕本発明では、レチクル上の像パターンは透明な部分が多い程良いので、像形成にあたって考慮する必要がある。像パターンによっては、ホトレジストの像の反転を施行した方が良い場合もありうる。

〔００２０〕本発明ステツパで製造したＬＳＩは、中心部に平板鏡の小孔に対応する欠損部が存在するが、小孔は直径１ｍｍ程度であるので、ＬＳＩ集積度に対する影響はない。もちろん光源の光量を大きく出来れば、小孔の直径はもっと小さく設定できうる。

〔００２１〕〔実施例〕実施例について図面を参照して説明すると、図１においてキセノン灯１，フイルタ２，スリット３，回転楕円凹面鏡４，レチクル５，平面鏡７の小孔８，放物面鏡１０，平面鏡７，透明窓板１１，ウエハ１２，とこの順序でキセノン灯１からの光の光学的通路に設置し、回転楕円凹面鏡の一方の焦点にスリット３，もう一方の焦点に平面鏡７の小孔８を設置する。又小孔８は同時に放物面鏡１０の焦点ともなっている。この時平面鏡７の鏡面９は放物面鏡１０と向かいあって設置され、小孔８の周囲には電気集塵装置６が取り付けられている。

〔００２２〕キセノン灯１の代りにＡｒＦ，ＫｒＦ等の数種類のガスを混合し、発振波長を動揺さすエキシマレーザーを光源とした実施例がある。

〔００２３〕透明窓板１１の代りに収差補正用レンズを使用した実施例がある。

〔００２４〕放物面鏡１０の代りに球面鏡，双曲面鏡等他の凹面鏡を使用した実施例がある。

〔００２５〕図２に示される実施例では、光学系の間の空間を透明な液体で満たし、その透明な液体を循環さし

ている。レチクル５は透明な液体を満たす槽１３に浸されている。

〔００２６〕〔考案の効果〕本発明は、以上説明したように構成されているので、以下に記載されるような効果を奏する。

〔００２７〕レチクル照射光源は、高コヒーレント光を使用し、回転楕円凹面鏡にてレチクルの前方の一点に集中さしているので、波長λ，回転楕円凹面鏡の口径Ｄ，焦点距離をｆとすると，γ＝１．２２ｆ／Ｄの半径内に全光量の８４．６％がレチクルの前方にある平面鏡の小孔に集中する．小孔の周囲はレチクルの回折像となるが、小孔の中心部は小孔の光の波長の幅の周辺リング状のフチ部と比較して極めて高い光量となるので、小孔のフチ部を光が通過して回折が生じるその割合は極めて小さくなっている。従って光が小孔を通過することによる解像力の低下は極めて小さい。この効果は小孔がγ＝１．２２λｆ／Ｄの半径に近づくにつれて大きくなる。

〔００２８〕ウエハの表面上の像の各点に到達する光の大部分は、放物面鏡の対応する極めて小さい範囲で反射されたものであるので、焦点深度も深く像面彎曲や像面歪曲以外の収差は極めて小さくなっている。

〔００２９〕又ウエハの表面上の像の各点に到達する光の大部分は、放物面鏡の対応する極めて小さい範囲で反射されたものであるので、放物面鏡の計算上な開口数より実効開口数は大きくなる。

〔００３０〕照射光源に高コヒーレント光を使用すると、レチクル像の回折現像でスペツクル雑音等が出現するが、レチクル像の１０分の１程度に縮小するタイプであるため、レチクル像パターンを大きくとる事ができることと、色収差がないので波長域幅を広くとることにより、高コヒーレント光を光源に使用しても像の劣化はな＊

＊い。

〔００３１〕本発明ステツパで、露光面積φ３０ｍｍ程度、計算上の開口数０．３５程度、（実効開口数はもっと大）が得られる。

〔００３２〕本発明は、ミラータイプの光学系を使用しているので、レンズタイプの光学系使用ステツパより短波長紫外線を使用できる。

〔００３３〕光学系の間の空間を透明な液体で満たすことにより、光の波長をλ，透明な液体の屈折率をηとすると，λ／ηの光を使用したと同じ効果がある。

【図面の簡単な説明】

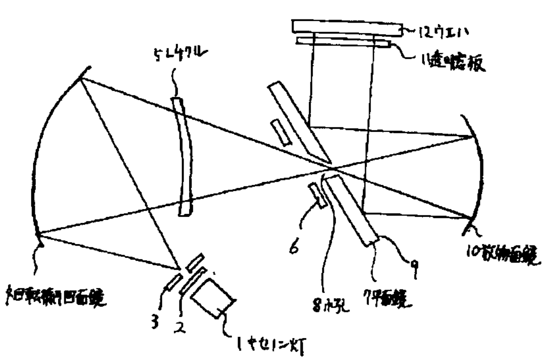
〔図１〕本発明ステツパの１実施例の構成ブロツク図である。

〔図２〕本発明ステツパの光学系間を透明な液体で満たした実施例のレチクル周辺部の構成図である。

〔符号の説明〕

１　キセノン灯
２　フイルタ
３　スリツト
４　回転楕円凹面鏡
５　レチクル
６　電気集塵装置
７　平面鏡
８　小孔
９　平面鏡の鏡面
１０　放物面鏡
１１　透明窓板
１２　ウエハ
１３　透明な液体を満たす槽
１４　光学系を満たす透明な液体の流れ

【図１】



【図２】